NOAA SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP)
PROJECT ANNUAL REPORT (DRAFT)

PROJECT TITLE

Climate Variability, Urban Floods, and Stakeholder Capabilities: Linking Severe Weather Impacts to Community Users with Modeling and Visualization

INVESTIGATORS
(Research team and full contact information)

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PROJECT YEARS **9/01/11-8/31/13**

TIME PERIOD ADDRESSED BY REPORT *(e.g., August 2002-March 2003)*

September 2011 – May 2012

I. PRELIMINARY MATERIALS

A Project Abstract *(Limit to one page)*

Urban floods have long been problematic hazards for cities to respond to effectively. Current and future climate variability can be expected to place additional burdens on cities to design and develop workable flood hazard mitigation actions as well as sustainable infrastructure plans. This proposal addresses the challenge for urban communities to properly anticipate and plan for flood events by engaging a selected group in a two-year project that will identify and characterize potential flood hazards, model the potential impacts associated with specific flood events, and develop computer visualization techniques that will enable local planners and decision makers to better understand the ramifications of current and potential future flood hazards in their region. The research team will work closely with the six-state NOAA Southern Climate Impacts Planning Program (SCIPP) RISA. While the SCIPP is oriented more toward multi-hazard planning and management, this proposal is designed to focus more specifically on urban flood-hazard management by working with the SCIPP Stakeholder Services Committee, five test cities in the region, and their respective local focus groups. The proposed research will be conducted in three tasks. The first task will be based on the SCIPP team's characterization of extreme events and the development of an accessible database. The SCIPP data archive includes extreme events, including municipal floods, beginning in 1950 to the present. SCIPP climate assessments and projections for the years 2020, 2050, and 2100 will be used by the research team. The second task will be the conduct of urban case studies in Austin, Dallas, Houston, Oklahoma City and Tulsa that will be analyzed for detailed flood-hazard mitigation and organizational changes. Local focus groups will be recruited for each city. An initial survey questionnaire will be distributed to the focus groups to establish baseline conditions. The research team will detail the institutional and organizational structures and strategies undertaken in each of the five cities to gauge the capacity of local governments to plan for and respond to flood events. The third task will include the development of flood model scenarios in each of the study sites based on climate histories and climate change projections. Computer visualizations will be created to help local stakeholders prepare appropriate mitigation and/or adaptation strategies including the design of sustainable public works. Next, the practicality and value of the project visualizations to the focus groups will be evaluated. A second survey questionnaire whose findings will be compared to the first one will be distributed. The computer visualizations, which will be presented to the case study cities for their use, may be developed and expanded by the SCIPP team for application elsewhere.

B Objective of Research Project *(Limit to one paragraph)*

The scientific objectives of the proposed research are to:

1) In collaboration with the NOAA SCIPP team, the climatological records near urban areas will be studied and the regional and subregional precipitation recurrence intervals from long-term records examined. Advances in regionalized probability analysis support analysis and can offer new insights into trends affecting precipitation quantiles. Long-term record analysis will be conducted in the five metropolitan areas mentioned above. The team will look at changes in the relative risk (and monetary loss) over time in each location associated with shifts in climate variability, climate change, and changes in urban demographic patterns.

2) Conduct detailed case studies of the Austin, Dallas, Houston, Oklahoma City, and Tulsa metropolitan regions to determine the institutional factors which led them to either adopt or not adopt flood forecast warnings. Based on the results of the climatological assessment and knowledge of previous flooding events, the case studies will be conducted in concert with urban stakeholders to document the organizational changes and/or policy innovations that have improved the overall ability for state, and local entities to disseminate forecast information in a useable form to target audiences, and document through a survey the specific techniques by which organizational and institutional impediments to such changes have been overcome.

3) Design and develop site-specific flood modeling and visualization products and use them to communicate various impacts associated with future event scenarios, including climate change projections, to urban stakeholders. Urban focus groups comprised of relevant emergency management and public works planning and management personnel will be engaged by the research team to assess the effectiveness of modeling and visualization to alter natural hazards responses and infrastructure planning and management strategies in the study sites.

4) Upon completion of the third task, the team will conduct a follow-up survey of focus group members to measure the effectiveness of the modeling and visualization products, and to elicit what modifications might be made to improve their effectiveness. Additionally, a wider survey of the SCIPP metropolitan regions will be undertaken to help determine what organizational and institutional impediments to change exist, and what strategies could be undertaken to address them. In particular, the team will seek to identify and quantify the key organizational changes and innovations that can improve forecasting and warning dissemination and mitigation capabilities for urban flood forecasting, and determine the likelihood that such innovations may prove adequate to address future impacts associated with projected climate change hazards.

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C Approach (including methodological framework, models used, theory developed and tested, project monitoring and evaluation criteria) include a description of the key beneficiaries of the anticipated findings of this project (e.g., decision makers in a particular sector/level of government, researchers, private sector, science and resource management agencies) *(Limit to one page)*

Findings from the case studies and follow-up survey will be presented to city and state offices of emergency management to improve the ability of flood-prone organizations to adopt forecast warnings. Research results and case study discussions will be summarized and made available for wider public access, particularly in the NOAA SCIPP region, and by educational applications through peer publication and conference presentation

D Description of any matching funds/activities used in this project *(Limit to one paragraph)*

II. ACCOMPLISHMENTS

A. Brief discussion of project timeline and tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken, or analysis and/or evaluation undertaken, workshops held, training or other capacity building activities implemented. *(This can be submitted in bullet form – limit to two pages)*

Report attached after Section V below.

B. Summary of findings, including their potential or actual implications for efforts to develop applications, methods, and science-based decision support capacity/systems and to foster sustainable resource management and vulnerability reduction. *(Limit to two pages)*

Bullet Points:

- Five test cities and their watersheds have been selected for study: Oklahoma City (Chisholm Creek) and Tulsa (Fred Creek), OK and Austin (Lake and Rattan Creeks), Dallas (Joe's Creek), and Houston (Brays Bayou), TX.
- City contacts have been established with each of the cities and watershed data has been requested and received by the team.
- Global data have been accessed from 16 GCMs (The World Climate Research Programme's Coupled Model Intercomparison Project phase3 multi-model dataset).
- CONUS wide data have been accessed from 16 Statistical Downscaled and Bias-Corrected GCMs (The World Climate Research Programme's Coupled Model Intercomparison Project phase3 multi-model dataset).
- Model output used to derive the flood estimates has been accessed from the North American Regional Climate Change Assessment Program (NARCCAP) that predicts future climate from 2040 through 2070 based on the International Panel on Climate Change (IPCC) emissions Scenario A2.
- Geospatial data defining soils, topography, land use/cover, and imperviousness have been collected and assembled. Model parameters have been derived from the geospatial data to simulate infiltration and runoff processes.
- Model grids have been defined for each basin variously from 10 to 100 m resolution. For purposes of sensitivity testing, precipitation depths for 2, 5, 10, 25, 50, 100, and 500 yr. return intervals have been assembled for each of the basins.
- For testing current and future climate scenarios, precipitation data at 3-hr. intervals have been assembled for continuous simulation input. Initial model runs are being made to confirm model parameter choices and validity.

C. List of any reports, papers, publications or presentations arising from this project; please send any reprints of journal articles as they appear in the literature. Indicate whether a paper is formally reviewed and published. *(No text limit)*

Watershed Modeling and Visualization for Climate Planning and Adaptation:

An Analysis of Five Cities

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D. Discussion of any significant deviations from proposed workplan (e.g., shift in priorities following consultation with program manager, delayed fieldwork due to late arrival of funds, obstacles encountered during the course of the project that have impacted outcome delivery). *(Limit to one paragraph)*

E. Where appropriate, describe the climate information products and forecasts considered in your project (both NOAA and non-NOAA); identify any specific feedback on the NOAA products that might be helpful for improvement. (bulleted response)

III. GRAPHICS: PLEASE INCLUDE THE FOLLOWING GRAPHICS AS ATTACHMENTS TO YOUR REPORT

A. One Power point slide depicting the overall project framework/approach/results to date
B. If appropriate, additional graphic(s) or presentation(s) depicting any key research results thus far
C. Photographs (if easy to obtain) from fieldwork to depict study information (if applicable).

IV. WEBSITE ADDRESS FOR FURTHER INFORMATION (IF APPLICABLE)

V. ADDITIONAL RELEVANT INFORMATION NOT COVERED UNDER THE ABOVE CATEGORIES.

ACCOMPLISHMENTS

Attachment of Statement of Accomplishments for the First Year

The goal of this NOAA SARP Urban Water Resources Planning project is to simulate urban watershed flood events in five Oklahoma and Texas cities for present and projected future climate conditions, and present the simulated watersheds to urban planners and decision makers to determine the mix of possible modifications that might be made in urban flood planning and/or policy. To this end, the research team is comprised of a climatologist (S. Greene), a hydro-meteorologist (Y. Hong), an engineer/hydrologist (B. Vieux), and an environmental policy analyst (M. Meo). The five cities and their watersheds selected for study include: Oklahoma City (Chisholm Creek) and Tulsa (Fred Creek), OK and Austin (Lake and Rattan Creeks), Dallas (Joe's Creek), and Houston (Brays Bayou), TX. City contacts have been established with each of the five cities and watershed data has been requested and received by the team. In the sections below, we review current progress with: 1) Accessing projected climate change data and downscaling; 2) Accessing hydrological data for flood estimation; and 3) Urban watershed flood simulation.

1. <u>Accessing Projected Climate Change Data and Downscaling.</u>

The climate data we archived are listed as below:

Global data from 16 GCMs (The World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase3 (CMIP3) multi-model dataset):

- Three emission scenarios (A2, A1B and B1)
- Spatial resolution of 0.5 degree
- Temperature and precipitation
- Monthly time step
- Start from Jan. 1950 to Dec. 2099

CONUS wide data from 16 Statistical Downscaled and Bias-Corrected GCMs (The World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase3 (CMIP3) multi-model dataset):

- Three emission scenarios (35 runs for the A2 scenario, 39 runs for A1B, and 37 for B1)
- Spatial resolution of 0.125 degree

- Temperature and precipitation
- Monthly time step
- Start from Jan. 1950 to Dec. 2099

The 16 GCMs are listed as below:

Modeling Group, Country	WCRP CMIP3 I.D.	SRES A2 runs	SRES A1b runs	SRES B1 runs	Primary Reference [1]
Bjerknes Centre for Climate Research	BCCR-BCM2.0	1	1	1	Furevik et al., 2003
Canadian Centre for Climate Modeling & Analysis	CGCM3.1 (T47)	1...5	1...5	1...5	Flato and Boer, 2001
Meteo-France / Centre National de Recherches Meteorologiques, France	CNRM-CM3	1	1	1	Salas-Melia et al., 2005
CSIRO Atmospheric Research, Australia	CSIRO-Mk3.0	1	1	1	Gordon et al., 2002
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory, USA	GFDL-CM2.0	1	1	1	Delworth et al., 2006
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory, USA	GFDL-CM2.1	1	1	1	Delworth et al., 2006
NASA / Goddard Institute for Space Studies, USA	GISS-ER	1	2, 4	1	Russell et al., 2000
Institute for Numerical Mathematics, Russia	INM-CM3.0	1	1	1	Diansky and Volodin, 2002
Institut Pierre Simon Laplace, France	IPSL-CM4	1	1	1	IPSL, 2005
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC), Japan	MIROC3.2 (medres)	1...3	1...3	1...3	K-1 model developers, 2004
Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA	ECHO-G	1...3	1...3	1...3	Legutke and Voss, 1999
Max Planck Institute for Meteorology, Germany	ECHAM5 /MPI-OM	1...3	1...3	1...3	Jungclaus et al., 2006
Meteorological Research Institute, Japan	MRI-CGCM 2.3.2	1...5	1...5	1...5	Yukimoto et al., 2001
National Center for Atmospheric Research, USA	CCSM3	1...4	1...3, 5...7	1...7	Collins et al., 2006
National Center for Atmospheric Research, USA	PCM	1...4	1...4	2...3	Washington et al., 2000
Hadley Centre for Climate Prediction and Research / Met Office, UK	UKMO -HadCM3	1	1	1	Gordon et al., 2000

Global climate studies usually rely on Global Climate Models (GCMs), which simulate past climate and project future climate. GCM outputs have coarse resolutions and perform poorly at smaller scales, making these models inappropriate for regional impact assessment (Maurer et al., 2007). Therefore, downscaling techniques were applied to subset climate data from global scale to the study region. The two primary downscaling methods commonly used are dynamic and statistical (Giorgi et al. 2001; Wilby and Wigley, 1997). Dynamic downscaling takes into account regional features by applying Regional Climate Models (RCM) to the GCMs outputs and as a result performs better at capturing local processes and feedbacks but is relatively expensive to operate (Liang et al., 2006; Lo et al., 2008). Statistical downscaling relates large scale climate features to local climate using simple statistical relationship which is computationally less intensive, however less physically relevant and depend on the quality of the observational data (Maurer et al., 2007).

2. Accessing Hydrological Data for Flood Estimation.

The model output used to derive the flood estimates is from the North American Regional Climate Change Assessment Program (NARCCAP), and predicts future climate from 2040 through 2070 based on the International Panel on Climate Change (IPCC) emissions Scenario A2. NARCCAP data is very useful as it simulates climate at high resolutions needed for regional climate studies. NARRCAP looks to solve the uncertainties of regional scale future climate projections and produce higher resolution climate data than is currently available. The higher resolution modes are created by using regional climate models (RCMs) which are nested within the large scale general circulation models (AOGCMs) forced with the A2 emission scenario. Output from NARRCAP is climate data at 50 km grid resolution, and three hour temporal resolution across the study area.

After driving the RCM with the reanalysis data, the NARCCAP model was run with the boundary conditions from an atmospheric-oceanic general circulation model (AOGCM) model from the Geophysical Fluid Dynamics Laboratory (GFDL), more specially known as AM2.1 The GFDL created the AM2.0 and AM2.1 models to simulate past climate and used the data from this model to enhance the GFDL™s GCM performance. This model was created to simulate atmospheric and oceanic climate and variability from the diurnal time scale through multicentury climate change (Delworth et al. 2006, 643). NARCCAP uses this model because it is a good resource for modeling past climate and when compared to observations the model is highly credible. The GFDL AM2.1 has a resolution of 2 degrees latitude and 2.5 degrees longitude for the land and atmospheric components with 24 different vertical levels. For the oceans, the model has a resolution of 1 degree for both latitude and longitude with 50 vertical levels. The historical dataset is based on not only reanalysis data provided by NCEP but also the boundary conditions derived by perturbing the same observed sea-surface temperature and ice data by an amount based on the results of a lower-resolution run of the full AOGCM • (NARRCAP, 2011).

3. Urban Watershed Flood Simulation.

Data have been collected for five urban basins, Brays Bayou in Houston TX, Joe’s Creek in Dallas TX, Lake and Rattan Creeks in Austin TX, Chisholm Creek in Oklahoma City OK, and Fred Creek in Tulsa OK. Geospatial data defining soils, topography, land use/cover, and imperviousness have been collected and assembled. Model parameters have been derived from the geospatial data to simulate infiltration and runoff processes. Model grids have been defined for each basin variously from 10 to 100 m resolution. For purposes of sensitivity testing, precipitation depths for 2, 5, 10, 25, 50, 100, and 500 yr return intervals have been assembled for each of the basins. For testing current and future climate scenarios, precipitation data at 3-hr intervals have been assembled for continuous simulation input. Initial model runs are being made to confirm model parameter choices and validity.

In the near term, completed watershed simulations will be visualized and be presented to each of the five city contact/liaison people to determine the most appropriate output parameters and presentations that can be used effectively to guide planning and decision making. The watershed visualizations and output packages will then serve as the basis for subsequent interactive dialogues with city flood planning and management units.

References:

Giorgi F et al. (2001) Regional climate information: Evaluation and projections, in Climate Change 2001: The Scientific Basis—Contribution of Working Group I to the Third IPCC Assessment Report, edited by J. T. Houghton et al., chap. 10, pp. 583–638, Cambridge Univ. Press, Cambridge, U.K

Liang XZ, Pan J, Zhu J, Kunkel KE, Wang JXL, Dai A (2006) Regional climate model downscaling of the U.S. summer climate and future change. J Geophys Res, 111, D10108, doi:10.1029/2005JD006685

Lo JCF, Yang ZL, Pielke Sr. RA (2008) Assessment of three dynamical climate downscaling methods using the Weather Research and Forecasting (WRF) model. J Geophys Res, 113, D09112, doi:10.1029/2007JD009216

Maurer EP, Brekke L, Pruitt T, and Duffy PB (2007) Fine-Resolution Climate Projections Enhance Regional Climate Change Impact Studies, Eos Trans. AGU, 88(47), doi:10.1029/2007EO470006

Wilby RL, Wigley TML (1997) Downscaling general circulation model output: A review of methods and limitations. Prog Phys Geogr, 21:530–548